Fig. 2 is a fragmentary diagrammatic illustration of an alternative embodiment of the supersonic corona discharge source of Fig. 1.

Detailed Description

In Fig. 1, a corona discharge supersonic free-jet source 20 has a quartz tube 22 (6 mm O.D., 4 mm I.D.), which has been heated and drawn to closure then ground back to form a nozzle orifice 23 with diameter of 200 μm as measured by an optical comparator. The tube 22 is mounted in a ¼" Swagelock cross 25 to allow as one electrode a tungsten or rhenium corona wire 26 (diameter 0.25 mm) to be inserted via a high voltage feedthrough 28 welded into the opposing leg of the cross. Source gas enters through one transverse leg 29 of the cross 25 as indicated at 31. The opposing leg 33 serves as the means of mounting the cross on a ¼" stud 34, all within a source vacuum chamber 36. The nozzle was operated at a stagnation pressure of typically 200-440 Torr, producing a background pressure of 1×10^{-6} torr in the source vacuum chamber 36 pumped by an 18,000 l/s diffusion pump 37. A circular auxiliary electrode 38 was positioned just downstream of the nozzle, outside of the free-jet boundary, to provide a point of attachment for the corona discharge. The discharge can be operated with the corona wire 26 either positive or negative with respect to the circular electrode 38. A current limited high voltage supply 39 to the corona wire was ballasted with a 250 kΩ series resistor 41. Under these conditions a voltage of 4-6kV applied to the corona wire produces a discharge current of 6-18 mA and results in a readily discernible bright plume at the tip of the nozzle as diagrammatically shown at 42. The turn-on procedure is as follows. The source gas is raised to the desired pressure. The current limit of the high voltage power supply to the corona wire 26 is set to the desired discharge current. The voltage is raised until the discharge initiated, whereupon the current jumps immediately to the current limit, placing the power supply in its current-limited

mode. Once the discharge is struck, the emission current can be adjusted within bounds determined by the current-voltage characteristics of the discharge.

A custom-made refractory graphite skimmer 40, with a diameter 0.75 mm opening 43 at its apex, extracts the isentropic core of the free-jet plasma expansion to form a molecular beam. Skimmers of the kind used here are described in D.C. Jordan, R. Barling and R.B. Doak, Refractory Graphite Skimmers for Supersonic Free-jet, Supersonic Arc-jet, and Plasma Discharge Applications, 70 Rev. Sci. Instrum. 1640 (1999), incorporated herein by reference, and in U.S. provisional patent application Serial No. 60/092,815 of Jordan, Barling and Doak, filed June 8, 1998, also incorporated herein by reference. The shape and the very sharp edge of the front of the skimmer allow a shock wave to attach to the front of the skimmer. In this aerodynamic flow configuration, the central portion of the beam passes into and through the skimmer without being influenced by the skimmer edge. Further downstream of the skimmer, where the beam density is much less, simple apertures in flat plates can be used as collimators 52--52_n for further collimation of the beam. Downstream of the skimmer, several differentially pumped stages 44--44_n lead to a deposition chamber 46 where controlled growth can take place under UHV molecular beam epitaxy (MBE) conditions.

The differential pumping is employed to ensure that essentially only the collimated, directed beam provides reactants to the surface 49 of a target substrate 50 supported in a final chamber 46 by a suitable means for locating the substrate as is diagrammatically indicated at 51. Background gases in the various vacuum chambers 44--44_n also flow through a series of collimators 52--52_n separating one chamber from the next. As mentioned, these may be simply small openings in the wall separating one chamber from another or one or more may be a skimmer similar to the skimmer 40. There occurs what is called "effusion" of the background